QUARTERLY REPORT

1. **Contract Number:** DAMD17-91-C-1081

2. **Report Date:** 15 December 1993

3. **Reporting Period:** 16 August 1993 to 15 November 1993

4. **Principal Investigator:** Dr. Robert W. Verona on permanent long-term disability. Dr. Victor Klymenko is acting Project Director.

5. **Telephone:** (205) 598-6389, FAX (205) 598-9256

6. **Institution:** UES, Inc.
4401 Dayton-Xenia Road
Dayton, Ohio 45432

7. **Project Title:** Development of Data Packages on the Human Visual Response with Electro-optical Displays

8. **Current staff, with percent effort of each on project:**

NAME	TITLE	HOURS*	% OF EFFORT
Dr. Robert W. Verona*	Engineering Psychologist	0	0%**
Dr. Victor Klymenko	Research Psychologist	484	83%
Mr. Howard H. Beasley	Electronics Technician	528	90%
Mr. John S. Martin	Electro-optics Technician	571	98%

584 hours were available this reporting period not including holidays. The above hours are the actual hours worked (sick leave and vacation have been subtracted).

* As of 21 June 1993 Dr. Verona was temporarily on sick leave and placed on permanent long-term disability as of 4 November 1993.

9. **Contract expenditures to date:**

Personnel	$560,942.93	Equipment & Supplies	$ 5,603.50
Travel	10,617.55	Other	5,128.23
		TOTAL*	$582,292.21

* Does not include facilities capital and G&A expense.

10. Comments on administrative and logistics matters:

Building construction has continued to disrupt the office work area for most of this reporting period. Dr. Robert Verona has been placed on permanent long-term disability by UES' insurance company UNUM as of 4 November 1993. His medical condition will be evaluated by Army Medical Staff (at Lyster Army Hospital and Walter Reed Medical Center) every ninety days.

11. Scientific Progress:

Physical Measurements:

A significant amount of time this quarter was spent in preparation of a meeting with Army Surgeon General LTG LaNoue to review and demonstrate alternative (medical) uses of new helmet mounted display technology. The demonstration included four flat panel display technologies (liquid crystal display, active matrix color liquid crystal display, plasma display and electroluminescent display). These were used to display medical imagery for application to a head mounted concept. Preparation for the demonstration included setting up the physical interface configurations and the supporting computers as well as generating graphic images and software to control the flat panel displays. In addition, the VII pattern generator was tested with the active matrix flat panel display.

A demonstration and discussion of our research and techniques was conducted for visitors from Kaiser and Honeywell.

Reports are in preparation that include the measurement procedures and descriptions of hardware and the software developed for evaluating the performance of night vision devices in three areas: field-of-view, magnification and distortion. A methodology paper documenting the hardware and the control software used in measuring the night vision devices is also in preparation. For this paper, the image intensifier measuring system (IIMS) measuring field-of-view, magnification and distortion measurement system has been reconfigured and calibrated to make verification checks with various ANVIS systems. The control software has been updated to make it more efficient and user friendly. Tests were run on ANVIS systems and results documented. Repeatability of results has been very good.

To obtain the dynamic modulation transfer function (MTF) of a display system, equipment has been set up to measure the input voltage to output luminance of dynamic (drifting) sine wave gratings. The system allows one to display, digitize and printout input video signals. The equipment assembly, including optical and electronic alignment and machine work has been

completed and testing has begun. Work on the paper documenting the dynamic sine wave response of CRT displays is in progress.

Psychophysical Measurements:

Three reports have been completed and sent to corporate UES for editorial and scientific review. The reports describe a series of visual performance experiments testing the effect of different factors used in helmet mounted displays. Copies of the reports have been forwarded to Dr. Wiley.

The first report on luning (Experiment 2 under the protocol "Psychophysical Assessment of Visual Parameters in Electro-optical display systems") documented the effect of a number of factors on the magnitude of luning, a detrimental visual effect due to binocular rivalry and suppression characterized by a subjective darkening of the visual field in the monocular regions of partial binocular overlap displays. The factors tested included: (1) the convergent versus the divergent display modes for presenting a partial binocular overlapping field-of-view, (2) the display luminance level, (3) the placement of either black or white contours versus no (null) contours on the binocular overlap border, and (4) the lowering or raising of the luminance of the monocular side regions relative to the binocular overlap region. The results indicated that the divergent display mode systematically induced more luning than the convergent display mode under the null contour condition. Adding black contours reduced luning in both the convergent and divergent display modes, where the convergent mode retained its relatively lower magnitude of luning. The results confirmed the data reported by Kaiser. The display luminance level had no effect on luning for the null or black contour conditions. Adding white contours, reduced luning by an amount which depended on display luminance, where there was less luning for lower display luminance levels, but no systematic effect of display mode. Changing the luminance of the monocular regions (relative to the binocular overlap region) reduced the amount of luning, where a decrease in luminance produced more of a reduction in luning than an increase. In conclusion, all other factors being equal, when a partial binocular overlap display is needed to present a larger field-of-view to aviators in helmet mounted displays, the convergent display mode with black contours on the binocular overlap borders appears to be the most reliable of the conditions tested to systematically reduce luning.

The second report (under a protocol amendment) documented the effect of a number of factors on fragmentation, an effect related to luning. With sufficiently small visual fields, luning is experienced as fragmentation of the field-of-view into three regions, with the binocular overlap region appearing to be distinct and phenomenally segregated from the monocular side regions. Visual fragmentation is the result of the binocular rivalry and suppression caused by the dichotic competition between the images in the two eyes. The effect of the following factors on fragmentation were investigated: (1) the display mode-convergent versus divergent, (2) the size of the monocular regions, (3) the size of the monocular fields, (4) the size of the field-of-view,

and (5) the size of the binocular overlap region. The results showed that the divergent display mode systematically induced more fragmentation than the convergent display mode and also that patterns with a smaller binocular overlap region tended to fragment more than patterns with a larger binocular overlap region. The remaining three factors had no influence on fragmentation.

Neither optical convergence nor the retinal location of the blind spot were shown to be important factors. In conclusion, all other factors being equal, when a partial binocular overlap display is needed to increase the field-of-view to aviators in helmet-mounted displays, the convergent display mode with the larger binocular overlap region appears to be the best of the conditions tested to attenuate the fragmentation effect of luning.

The third report (Experiment 1 under the protocol) documented the effect of three display modes on visual sensitivity across the field-of-view. Visual sensitivity is known to be lower in monocular regions. It was hypothesized that visual thresholds would be highest in the divergent mode, where luning was most severe, and lowest in the full overlap mode, where there was no dichotic competition. For the full overlap, the convergent and the divergent display modes, we the visual threshold to probe targets across the field-of-view were measured. The experimental conditions included four types of position in the field-of-view: monocular and binocular, each of which could be either adjacent or nonadjacent to the binocular overlap border. Four spatial and four temporal frequency probe targets were tested at each of the four locations. As expected, the probe target thresholds for monocular stimuli in the partial overlap display modes were higher than the thresholds for the binocular stimuli at the corresponding positions in the full overlap display mode. In general, thresholds were higher in the divergent than in the convergent display mode and this difference was greatest near the binocular overlap border. Overall these differences were more pronounced for the highest spatial frequencies.

For the last paper, an improved technique was used. Measurements of the physical contrasts of the 16 spatio-temporal stimulus variations of the stimulus probe patterns (4 spatial x 4 temporal frequencies) for the 256 (computer defined) values for each probe were taken. For each of the 16 stimulus probe types, second order regression equations were fit describing the functions transforming the digital to physical contrast values. The coefficients for these equations were incorporated into the statistical analyses programs and the results reported in the paper. Except for the absolute physical contrast values, the results were similar to the results previously reported at ARVO in May, 1993, where estimated equations of the digital to physical contrast functions were used. Also analyzed were the probe stimuli--sine wave patches with a cosine envelope--with a digital fast fourier program to determine their spatial frequency bandwidth.

Abstracts were sent to the SPIE Night Vision Psychophysics and Training Conference for April 1994, and to the Association for Research in Vision and Ophthalmology Convention for May 1994.

Milestones:

In addition to the completion of the reports following UES's scientific review, efforts for the next quarter will focused on three new (abbreviated) research protocols. The protocols, soon to be submitted, will focus on aspects of binocular vision relevant to helmet-mounted displays. The issues to be addressed will include the effect on visual performance of the following: (1) binocular misalignment, (i.e., visual tolerance for misalignment), (2) binocular brightness differences, and (3) defocus in one eye. Literature research and the assessment of the software and equipment requirements for the abbreviated protocols has begun. Dr. McLean will be consulted on the assessment of the optical equipment requirements for the third protocol. The first protocol will be submitted at the beginning of the next quarter to be followed shortly by the other two protocols.

It has been requested by Dr. Wiley that we repeat the flat panel demonstrations for a second visit by Army officials who did not attend the first medical imagery demonstration.